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THIN FILMS AS HUMIDITY SENSORS

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ABSTRACT: Thin films TiO_2 were prepared on the interdigital electrode by dip – coating. We investigate electrical properties this films. The humidity sensing electrical properties of the films were evaluated using impedance spectroscopy measurements. The electrical a. c. measurements are made in the range 1 kHz – 1 MHz. The results of humidity sensitive properties of the films are discussed.

KEY WORDS: TiO_2 films, sol – gel, humidity sensor, electrical properties

1. INTRODUCTION

Thin films are using for the surface treatment of the different substrates. These thin films were prepared via a sol-gel method, which a great advantage is a control of structure and properties of resulting films on the nanolevel. Thin films are deposited often on the substrate at room temperature by spin – coating and dip – coating process. Over the last decades, sol – gel thin films have found wide applications in optical, microelectronics, photo – electronics industries. Meanwhile, they are more frequently applied for purpose of protection from scratching and corrosion. The unique structure of sol – gel films makes it possible to use the films as sensors. [1]

Sol – gel films belong to nanotechnology. It's based on the fact that some structures usually smaller than 100 nm have new properties and behaviour that are not exhibited by the bulk materials of the some composition. The one of the most important effects is due to the change in the surface/volume ratio. When the size of the structure is decreased, this ratio increases considerably and the surface phenomena predominate over the chemistry and physics in the bulk. Sensors have been classified according to multiple criteria. The most common way to group sensors considers either the transducing mechanism (electrical, optical, etc.), recognition principle or their applications. [2]

The most aspect of investigation of a variety of sensors is 3 „S", i.e. sensitivity, selectivity, and stability. The questions, that have been eliminated for investigation of sensors, are research the novel sensing materials, data analytical method, measurement techniques, control of sensors structures, sensor fabrication techniques, surface modification, etc. [3]

The chemical sensors are frequently used. The most important are the sensors of humidity and sensors for detection of different gases. They employ for the industry and for the household too. Ceramic sensors (sensors based on thin films prepare via sol – gel are ceramic sensors too) are attractive as they are essentially more stable thermally, chemically and physically than other material. The principle of sensor devices is based on their electrical response to the chemical environment. The principle of humidity measurement with ceramic sensors is the change in the electrical conduction and capacitance due to water chemisorptions and capillary conduction in the pores of the active sensor material. The electrical behaviour of the films has been evaluated at various relative humidity values to elucidate the effect of water adsorption on the humidity sensing mechanism. [4, 5]

Sensors based on TiO_2 or TiO_2 doped another compounds are frequently used as the chemical sensors. These sensors are on detection different gases, alcohol and humidity. Titanium dioxide (TiO_2) is a transition – metal oxide with a variety of applications. The sensing properties of TiO_2 thin films are based on its surface interactions with reducing or oxidizing materials which affects the conductivity of the film. [6]

Impedance characterization is now widely used to understand the operation of sensors. Impedance spectroscopy (IS) is nondestructive toll for analyzing many properties of (electroceramic) materials. In this technique, a small, single – frequency AC field is applied to a sample, and the amplitude and phase of the resulting current measured. The amplitude of the AC signal is chosen to be small enough to assume a linear response of the material. Usually the impedance is computed and analyzed. [7]

2. EXPERIMENTAL

Thin films TiO_2 were prepared using sol – gel method from alkoxide precursors. Precursor solutions was dip – coated on the substrates 60 $mm.s^{-1}$. After drying the films at 80°C and subsequently annealing at 500 °C, TiO_2 thin films were obtained. The substrates were a gold interdigitated electrodes with fine – grained structured Al_2O_3 ceramic substrate (Fig. 1). Impedance spectroscopy measurements was used from 50 Hz to 1 MHz. The equipment employed to obtain the impedance spectra was a RCL Meter PM 6306 Fluke. The experiments were conducted at room temperature in a various relative humidity.

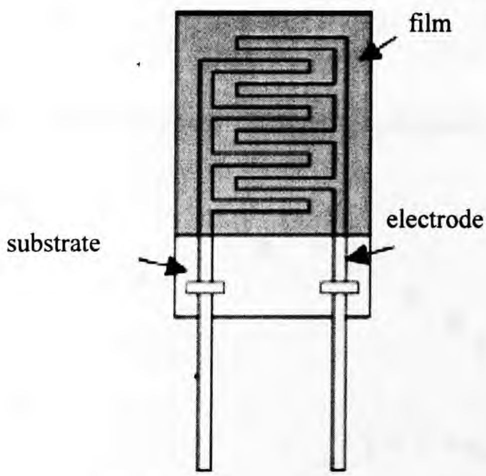

Fig. 1: Structure of sensor.

3. RESULTS

The electrical properties of TiO_2 thin films were measured in various relative humidity and the results are shown in Fig. 2 and Fig. 3. In porous material (that are our thin films too), water molecule gets adsorbed into the capillary pores. The amount of water adsorbed depends upon the pore size, temperature and ambient humidity. As dielectric constant of the water is very high, therefore capacitance of the porous material increases with increasing relative humidity. And, impedance of the porous material decreased with increasing relative humidity as shown Fig. 2. The most common graphical representation of the experimental impedance data is the complex – plane impedance diagram, called Nyquist diagram (Fig. 3). It describes the dependence real and imaginary part of impedance in Cartesian co – ordinates.

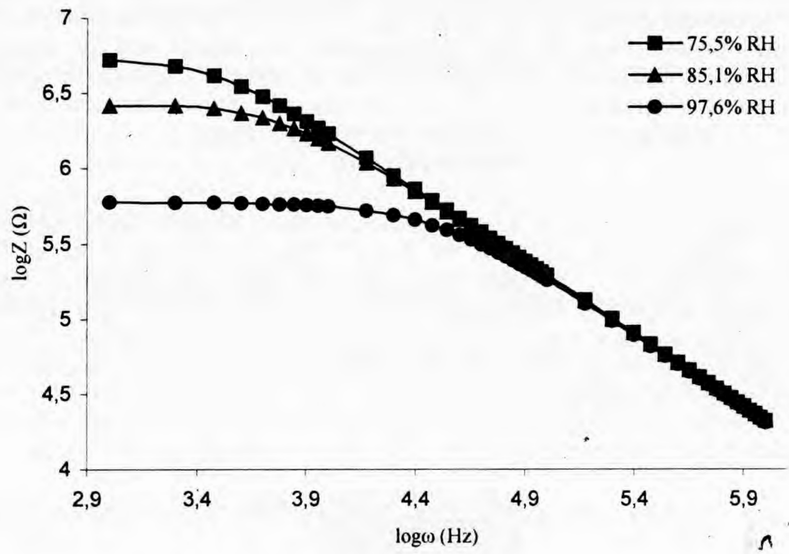

Fig. 2: Impedance vs. frequency for various relative humidity

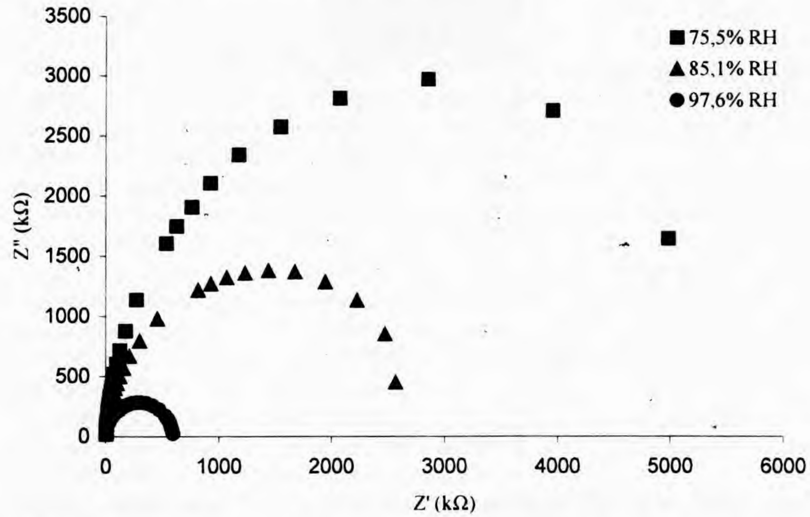

Fig. 3: Nyquist plot of TiO_2 thin films at room temperature and various relative humidity.

4. CONCLUSIONS

The sensors based on TiO_2 thin films were prepared by sol – gel method. The impedance spectroscopy showed the humidity – sensitive electrical behaviour of this films. The TiO_2 thin films sensors have shown good response to different relative humidity. The impedance of the films decreases with increasing relative humidity. Based on these findings, it is concluded that TiO_2 ceramic sol – gel thin film is a promising material for use as humidity sensor. One of the most interesting sensor is based on the system Al_2O_3 – SiO_2 – TiO_2, which we investigate in the near future.

5. REFERENCES

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